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REMOVAL OF IRON, MANGANESE AND CARBON DIOXIDE FROM WATER[1]

ROBERT SPURR WESTON: There was a very interesting case of decarbonation at a plant which the speaker cannot refer to by name. The works were originally supplied from ground-water sources. Lead poisoning developed to an alarming degree, and as a result the ground-water supply was abandoned in great part and slow sand filters installed, taking a very highly colored ground water, purifying it to a very good degree and supplying it to the city. The ground water in the beginning contained 55 parts per million of carbonic acid. When the slow sand filters were started, of course the carbonic acid content of the water furnished to consumers was reduced to practically that of the surface water, less than 10 parts per million, and the corrosion of the lead pipe services stopped immediately. After a period of about fifteen years of operation of the sand filters much coagulated brown vegetable matter accumulated in the sand, and the filters were so efficient that they converted this brown vegetable matter into carbonic acid, so that three years ago the amount of carbonic acid in the sand filter effluent was nearly what it was in the well water some years before and, strange to say, the wife of the attorney of the water company developed a very severe case of lead poisoning, and the matter had to be attended to.

Experiments were made similar to those made by the author and the conclusion was reached that aeration alone increased the corrosive action of the water on the lead surfaces to a great degree, and that the carbonic acid which was left in the water after aeration was more corrosive than the original amount without the oxygen. It was found, however, that the addition of very small amounts of either lime or magnesium oxide, the latter particularly, would practically prevent the corrosive action on the lead. The amount added was about 8 parts per million of quicklime or 6 parts per million of magnesium oxide, equivalent to about one-half grain to the gallon.

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[1] Discussion of a paper by Frank A. Barbour on "Decarbonation and Removal of Iron and Manganese from Ground waters at Lowell, Mass.," in the JOURNAL for June, 1917

This slight addition increased the hardness somewhat, but it was decided to apply the method. The addition of lime with aeration did not produce the best results. The water at that time contained over 1 part per million of lead and was treated with about 10 parts per million of lime.

This application was immediately followed by a reduction in the amount of lead and now, nearly at the end of the third year of operation, the lead in the water in ordinary use has been reduced to about 0.08 part per million; and in conditions where the water stands in services over night, to about 0.26 part per million; in both cases considerably less than the permissible amount. As to "permissible amount," the speaker believes that any lead at all in water is injurious, because the result is cumulative. The people noticed a slight increase in hardness after treatment, less than 35 parts per million but they have made no complaint. All danger of lead poisoning seems to have been averted forever. This method is used in England in treating certain waters that are acid, and the treatment with lime simply cures the acidity of the water due to carbonic acid or organic acid.

The method of removal of iron and manganese from water must be predicated upon the character of the water. Iron and manganese dissolved in water will nearly always precipitate out as iron or manganese rust. Practically all that we can do is to hurry the operation. Where the water is hard, as it is in some of the western states and in Germany, simple aeration and filtration is all that is required; in these cases it does not seem to make much difference whether you use slow filters or rapid or whether you use tricklers or not; but the removal of small amounts of iron from soft water is more difficult. Small amounts of iron in conjuction with manganese, or in conjunction with coloring matter, require more time than where the amounts of iron and manganese are large.

The most difficult water that the speaker has had to treat has been in his own house; the water has only 0.5 part per million of iron and considerable manganese, but a great deal of coloring matter. Another difficult case was the water supply at Cohasset, Mass., where a mechanical filter was first installed, which removed the iron perfectly and also the manganese without the use of coagulants. Within the last three or four months the color of the raw water, due to a near-lying peat bog, has increased so greatly that it has been necessary to add sulphate of aluminum to the water before passing it to the filter.

As to the choice of filters, the speaker believes that when a sand filter operating at a rate of 10,000,000 gallons per acre daily will do the work it will prove cheaper in practice, as a rule, than a mechanical filter at a rate of 125,000,000 gallons. Where the mechanical filter rate can be increased, where the head conditions are favorable, it may prove cheaper, and where the iron or manganese respond readily to treatment there is no reason why a mechanical filter should not be used where economic conditions favor it.

Recently, Dr. Corson prepared a paper in which he ascribes a great deal of the removal of manganese to the presence of a catalytic agent, that is, an agent which carries oxygen or effects the removal of the iron by catalysis. In Germany they have made similar experiments; they have, for instance, used shavings impregnated with tin oxide and various compounds supposed to be oxygen carriers, and passed these iron waters over them, with good results. However, it appears that other German investigators have shown that the same results can be obtained with sand filled filters. It has been shown that the film of iron or manganese hydrate on the surface of the sand will absorb oxygen, store it, and give it off. So the speaker is not yet in a position to accept the theory of catalysis, that it is the carrying of the oxygen by the oxide or the hydrated oxygen precipitated on the filter material which does the work; but rather that the iron and manganese which are readily oxidized are held in a fine collodial suspended condition and are absorbed by the film on the sand and held there until coagulation can take place, after which the film gradually increases in bulk until it sloughs off the trickler and is precipitated in the subsiding basin, or is removed from the surface of the sand filter.

At Middlesboro, in a plant somewhat similar in design to the author's but very much smaller, it was found that during the first year the manganese was reduced from about 0.56 to 0.15 part per million, but during the second year it was completely removed. The iron at Middlesboro has been reduced to an average of about 0.25 part per million.

During experiments at Brookline, contrary to the Lowell experience, it was found that the more contact of the water with air the better were the results that could be obtained. Again the speaker would say that what will work with one water will not work with another.

At Stargard, in Germany, where the iron and manganese are removed quite readily, the red discoloration or precipitation of iron is observed in the upper few inches of the gravel filter. Below that there are about 6 inches of clean gravel where neither iron nor manganese is being removed. Below the clean layer is a black layer where the manganese has accumulated, and below that clean gravel again, showing that the manganese oxidizes much more slowly than iron and requires more time, more contact, more help. It is for this purpose that subsiding basins, coagulants, coke tricklers, etc., are used to treat soft colored manganiferous waters before filtration.

JOSEPH RACE: The speaker could corroborate the statements just made regarding the plumbo-solvency of the waters in the north of England. Almost all water derived from the uplands situated near the Pennine range was in this category and required treatment of some kind to rectify this condition. The generally accepted hypothesis in England was that the action on lead was due to the presence of humic and other organic acids and it had been found that the plumbo-solvency could be rectified by the addition of caustic lime or soda or carbonates of lime or soda. The experiments made by Heap at the Manchester University appeared to indicate that oxygen and not carbonic acid was the most potent factor in the solution of lead, but as these results were obtained with waters that are very different from that treated by the author the problems are not analogous.

EDWARD BARTOW: With respect to iron removal in Illinois, two methods are employed. One is used at Freeport, where lime is used to remove the iron, the other at Champaign, where aeration and filtration with mechanical filtration removed about 2 parts per million, giving very satisfactory results.

Recently the Illinois Water Survey was asked for advice concerning a proposed water supply for Johnson City in the coal mining district. The problem was to remove 95 parts per million of iron from water having 4200 parts residue. Compare that with the 2 parts per million of iron which it is necessary to remove at Lowell from a water having a residue of about 34 parts per million, less than 0.01 per cent of the amount in the Johnson City water supply. It was proposed to remove the iron by aeration and mechanical filtration. The resultant water could not be very satisfactory because the treated water would contain about 3000 parts per million of sodium sulphate, which would surely have a bad effect on those not accustomed to its use.

For manganese removal, the speaker has tried experimentally the zeolites and also aeration and filtration. The zeolites as used in Europe will remove manganese; but manganese dioxide itself, or manganese dioxide developed on the sand grains, was efficient. The manganese dioxide was developed on the sand either artificially by means of alkali and a manganese salt or by very slow accretion after the filter was put in operation. There are two plants in the state which are removing manganese by means of mechanical filters where the sand grains have been coated with the manganese dioxide.

It is interesting to note the change in operating at a plant near Berlin, Germany; formerly aeration over baffles followed by slow sand filtration was used, but in a new plant opened in 1914 aeration by spraying, followed by a mechanical filtration, is used.

Samuel B. Applebaum: There are two questions the speaker desires to ask the author: First, in regard to the effect of increasing the amount of dissolved oxygen in the water upon aeration; has the author made any experiments as to the effect of aerated water on iron pipes in addition to his experiments on lead pipes, in order to ascertain the relative corrosiveness? He observed the interesting fact that the use of aeration was preferable to the use of an alkali to eliminate the corrosive effect of the water on lead. It would have been interesting if he had also tried experiments to ascertain whether the same effect, or the contrary, was true regarding the corrosiveness of the aerated water as compared with lime-treated water upon iron piping.

The second question is whether the author has made any experiments with the use of zeolites coated with higher oxides of manganese for the removal of iron and manganese in the Lowell supply? Abroad there are many municipal plants making use of these contact zeolites for the removal of iron and manganese from water. There are six or seven plants in operation today in Germany, notably those at Dresden, Glogau, and Wilhelmsburg, which are removing iron and manganese by this method. There is also one plant in England near Liverpool that is using these contact zeolites for the removal of iron and manganese followed by a sodium-zeolite plant for the removal of hardness. In this country there are two small municipal installations using this method, one at Helmetta, N. J., and the other at Weyanoke, Va., where the treated waters are free from iron and manganese, and are used for domestic purposes.